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SIGNIFICANT CHANGES FROM LAST BULLETIN ON THIS SUBJECT NO. 459

This bulletin, prepared by Y. Y. Chao, L. D. Burroughs, and H. L. Tolman of the Marine Modeling and Analysis Branch (MMAB), Environmental Modeling Center (EMC), National Centers for Environmental Prediction (NCEP), describes automated wave guidance for Western North Atlantic and adjacent waters in alphanumeric and Gridded Binary (GRIB) formats. This guidance was implemented operationally on the IBM mainframe computer in January 2000.

The WNA is based on the NOAA WAVEWATCH-III (NWW3) which is described in detail in Technical Procedures Bulletin (TPB) 494 (Chen, Burroughs, and Tolman 2003) and Tolman (2002). The NWW3 provides the boundary conditions to the WNA. The domain extends from 98.25°W to 29.75°W and from 0.25°S to 50.25°N with a grid resolution of 0.25° by 0.25° in latitudinal and longitudinal directions.

Various graphics and text products for the WNA are available at http://polar.wwb.noaa.gov/waves/, and available for anonymous ftp at ftp://polar.wwb.noaa.gov/pub/waves.

The following wind and wave parameters are available in GRIB format at the web site above and on AWIPS as GRIB bulletins: H_s, D_m, T_m, peak wave period and direction, wind sea peak period and direction, wind speed and direction, and u- and v-wind components.

Spectral text bulletins for the WNA are available at the web site above. These files are in ASCII and are available by anonymous at the ftp site above. These bulletins have been implemented on AWIPS, but with a condensed format necessitated by the capabilities of the communications gateway and display capabilities of AWIPS.

The WNA wave guidance is generated four times daily out to 168 hours based on the 0000, 0600, 1200 and 1800 UTC cycles of the Global Forecast System.

Technical Procedures Bulletin No. 459 is now operationally obsolete

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U.S. DEPARTMENT OF COMMERCE **National Oceanic and Atmospheric Administration**

WAVE FORECASTING FOR THE WESTERN NORTH ATLANTIC and ADJACENT WATERS

By
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1. Introduction.

In order to predict wave conditions adequately over the continental shelf and near land boundaries, a regional model which has higher resolution in grid space and possibly in spectral components is required. The regional model also must calculate rigorously the effects of submarine bottom conditions and any currents which may exist on wave growth, transformation and dissipation. A global-scale wave model usually is designed only to provide the general wave pattern over the deep ocean. It does not provide information accurate enough to describe small-scale, complex wave patterns near the coastal areas.

The Western North Atlantic (WNA) regional wave model was designed to fill the needs of the Eastern and Southern Regions, the Ocean Prediction Center (OPC) and the Tropical Prediction Center (TPC) which had requested that the domain of the model be from 50°N south to the Equator and from the coast of the Americas east to 30°W with the entire Caribbean Sea included. The boundary conditions are provided by the NOAA WAVEWATCH III (NWW3).

The WNA was implemented in January 2000 and is based on the NWW3 which is described in detail in Technical Procedures Bulletin (TPB) 494 (Chen, Burroughs, and Tolman 2003) and Tolman (2002). The NWW3 provides the boundary conditions to the WNA. Its domain extends from 98.25°W to 29.75°W and from 0.25°S to 50.25°N with a grid resolution of 0.25° by 0.25° in the latitudinal and longitudinal directions.

The following wind and wave parameters are available in GRIB format at the web site below and on AWIPS as GRIB bulletins: H_s, D_m, T_m, peak wave period and direction, wind sea peak period and direction, wind speed and direction, and u- and v-wind components. These graphics and text products for the WNA are available at

http://polar.wwb.noaa.gov/waves/.

The text files are in ASCII and are available by anonymous at

ftp://polar.wwb.noaa.gov/pub/waves/date.cycle,

where date represents the date in yyyymmdd format and cycle represents the run cycle identifier (t00z, t06z, t12z or t18z, respectively). These bulletins have been implemented on AWIPS, but with a condensed format necessitated by the capabilities of the communications gateway and display capabilities of AWIPS. See fig. 1 for a sample bulletin and Table 1 for the list of points having spectral wave bulletins, their locations, and their bulletin headers.

The WNA wave guidance is generated four times daily out to 168 hours based on the 0000, 0600, 1200 and 1800 UTC cycles of the Global Forecast System (GFS; Kanamitsu *et al.* 1991 and Caplan *et al.* 1997).

2. Model Description

Regional wave forecasts for Western North Atlantic and adjacent waters are generated at NCEP by using the WNA model. Fields of directional frequency spectra in 24 directions and 25 frequencies are generated at one hour intervals up to 168 hours. The 24 directions begin at 90 degrees to the east and have a directional resolution of 15 degrees. The 25 frequencies used by the WNA are given by bin in Table 2.

Figure 2 shows the domain of interest and the depth field which is derived from bathymetric data available from the National Geophysical Data Center. Required input wave spectral data for the boundary grid points of the WNA are obtained by linearly interpolating the spectra of neighboring grids of the NWW3. The wind fields driving the model are obtained from the output of NCEP's operational Global Data assimilation System (GDAS) and the GFS. The wind fields are constructed directly from spectral coefficients of the lowest sigma level at 0.5° x 0.5° longitude and latitude resolution, and are interpolated to the resolution of the wave model grid. They are converted to 10 m winds by using a neutrally stable logarithmic profile. Air and sea temperature data are obtained from the lowest sigma level air temperatures of the GFS and the sea surface temperature available in the model are used in the model wave growth parameterization. Finally, the wave model incorporates a dynamically updated ice coverage field in the region. These data are obtained from NCEP's operational automated passive microwave sea ice concentration analysis (Grumbine 1996; updated daily). Ocean currents are not considered in the model at the present.

The model runs four times daily for the 0000, 0600, 1200 and 1800 UTC cycles. GDAS wind fields from the previous 12 hours at 3-h intervals (analyses and 3-h forecasts) are used for a 12-h wave hindcast. Winds from the GFS at 3-h intervals out to 168 hours are used to produce wave forecasts up to 168 hours at hourly intervals.

3. Performance Evaluation

The WNA was extensively evaluated prior to its implementation in January 2000 and continues to be evaluated on a regular basis. It has been consistently shown to have less error and higher correlation with observations than similar models.

4. Available Products and Dissemination

The following wind and wave parameters are available in GRIB format at

ftp://polar.wwb.noaa.gov/pub/waves,

and became available on AWIPS in software build 5.2.2: H_s, D_m, T_m, peak wave period and direction, wind sea peak period and direction, wind speed and direction, and u- and v-wind components. Spectral text bulletins are also available on the web at the site above and are on AWIPS.

a. GRIB bulletins

GRIB bulletins became available for use in AWIPS with software build 5.2.2. Table 3 gives the bulletin headers and their meaning. Bulletins are available at 6-h intervals from 00- through 72-h and at 12-h intervals from 72- to 168-h. Available parameters are H_s, D_m, T_m, peak wave period and direction, wind sea peak wave period and direction, and u and v components of the wind velocity. A 0.25 x 0.25 degree lon./lat. grid is used with a domain from 98.25°W to 29.75°W and from 0.25°S to 50.25°N.

b. Alphanumeric spectral messages

Spectral text bulletins are presented for numerous points of the WNA. These bulletins are in ASCII and are available on the INTERNET, and, in AWIPS (see section **c** for a description of the format). The line length of the table is 130 characters by 100 lines. The header of the table identifies the output location, the generating model and the run date and cycle of the data presented. At the bottom of the table, a legend is printed. The table consists of 8 columns. The first column gives the time of the model results with a day and hour (the corresponding month and year can be deduced from the header information). The second column presents the overall significant wave height (H_s), the number of individual wave fields with a wave height over 0.15 m that could not be tracked in the table (x). Individual wave fields in the spectrum are identified by using a partitioning scheme similar to that of Gerling (1992). In the remaining six columns individual wave fields identified with their wave height (H_s), peak wave period (T_p) and mean wave direction (dir, direction in which waves travel relative to North). Generally, each separate wave field is tracked in its own column. Such tracking, however is not guaranteed to work all the time. An asterisk (*) in a column identifies that the wave field is at least partially under the influence of the local wind, and, therefore, most likely part of the local wind sea. All other wave fields are pure swell.

c. Spectral text bulletins for AWIPS

The format for the spectral text bulletins sent to AWIPS is generally the same as that for the web, except that the period is to the nearest second, the wave heights are to the

nearest foot, the direction is from (meteorological, rather than oceanographic), the number of fields that couldn't be tracked is not given, and the asterisk indicating when a wave field is, at least, partially under the influence of the local wind is not shown. The bulletin width is 69 characters, which is a legacy of the teletype era and the display capability of AWIPS. A sample bulletin is shown in fig. 1 and the list of points for the NWW3 is given in Table1.

5. References

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http://polar.wwb.noaa.gov/mmab/papers/tn222/MMAB_222.pdf].

1. H. L. Tolman is a contractor with SAIC

2. OMB Contribution No. 172

Table 1. Name, location, and header information for spectral text bulletins associated with the WNA regional wave model.

Station Name	Position (N and W, except where indicated)		AWIPS and WMO Header
	Latitude	Longitude	
Points for Wave Spectra from the Western North Atlantic (WNA) Regional Wave Model			
Northwest Atlantic Points			
44138	44.23	53.63	AGNT41 KWBJ OSBW01
44141	42.06	56.15	AGNT41 KWBJ OSBW02
44142	42.47	64.25	AGNT41 KWBJ OSBW03
44004	38.50	70.70	AGNT41 KWBJ OSBW04
44005	43.17	69.22	AGNT41 KWBJ OSBW05
44008	40.50	69.40	AGNT41 KWBJ OSBW06
44009	38.50	74.70	AGNT41 KWBJ OSBW07
44011	41.10	66.60	AGNT41 KWBJ OSBW08
44025	40.30	73.20	AGNT41 KWBJ OSBW09
OKX01	40.70	72.00	AGNT41 KWBJ OSBW10
44018	41.30	69.20	AGNT41 KWBJ OSBW11
BOX01	42.50	70.25	AGNT41 KWBJ OSBW12
CAR01	44.00	64.50	AGNT41 KWBJ OSBW13
Southwest Atlantic Points			
44014	36.58	74.84	AGNT42 KWBJ OSBW01
41001	34.70	72.60	AGNT42 KWBJ OSBW02
41002	32.30	75.20	AGNT42 KWBJ OSBW03
DSLN7	35.15	75.30	AGNT42 KWBJ OSBW04
41008	31.40	80.87	AGNT42 KWBJ OSBW05
41009	28.50	80.23	AGNT42 KWBJ OSBW06
41010	28.90	78.50	AGNT42 KWBJ OSBW07

Puerto_R_N	19.00	66.50	AGNT42 KWBJ OSBW08
ILM01	34.00	77.00	AGNT42 KWBJ OSBW09
ILM02	33.25	78.50	AGNT42 KWBJ 0SBW10
41012	30.00	80.50	AGNT42 KWBJ OSBW11
41004	32.50	79.10	AGNT42 KWBJ OSBW12
CHS01	30.75	77.00	AGNT42 KWBJ OSBW13
TPC20	15.00	55.00	AGNT42 KWBJ OSBW14
TPC24	22.00	76.00	AGNT42 KWBJ OSBW15
Gulf of Mexico Points			
42001	25.92	89.68	AGGX44 KWBJ OSBW01
42002	25.17	94.42	AGGX44 KWBJ OSBW02
42003	25.95	85.88	AGGX44 KWBJ OSBW03
42007	30.00	88.70	AGGX44 KWBJ OSBW04
42019	27.97	95.40	AGGX44 KWBJ OSBW05
42020	26.95	96.70	AGGX44 KWBJ OSBW06
42035	28.92	94.40	AGGX44 KWBJ OSBW07
42036	28.51	84.51	AGGX44 KWBJ OSBW08
42039	28.78	86.04	AGGX44 KWBJ OSBW09
42040	29.18	88.30	AGGX44 KWBJ OSBW10
TPC25	24.00	80.00	AGGX44 KWBJ OSBW11
TPC26	23.00	86.00	AGGX44 KWBJ OSBW12
Caribbean Sea Points			
Puerto_R_S	17.50	66.50	AGCA42 KWBJ OSBW01
TPC21	15.00	63.00	AGCA42 KWBJ OSBW02
TPC22	12.00	77.00	AGCA42 KWBJ OSBW03

TPC23	15.00	80.00	AGCA42 KWBJ OSBW04

Notes:

1. The WMO/AWIPS headers follow the form given for oceanographic data, *i.e.*, $AGA_1A_2i_1i_2$, where i_1 is 4 and always means spectral wave data.

2. i_2 is the geographic location, where:

   0 - means Pacific Ocean, particularly in proximity to U.S. held islands (Hawaii and Guam's areas of responsibility)
   1 - means proximity to NE Atlantic States from Virginia northward
   2 - means proximity to SE Atlantic States from North Carolina southward and Puerto Rico
   4 - means proximity to southern Gulf of Mexico states
   6 - means proximity to Pacific States and southern British Columbia
   7 - means proximity to Panhandle of Alaska and northern British Columbia (Juneau's areas of responsibility)
   8 - means proximity to southern and southwestern Alaska (Anchorage's areas of responsibility)

3. A_1A_2 is used by the originating office (NCEP/NCO) to identify the oceanic area of the point, where:

   NT - Western Atlantic
   GX - Gulf of Mexico
   CA - Caribbean Sea
   PZ - Eastern Pacific
   GA - Gulf of Alaska
   PN - North Pacific including Bering Sea
   AC - Arctic Ocean
   HW - Hawaiian Waters
   PW - Western Pacific
   XT - Tropical Belt
   PS - South Pacific

4. The AWIPS identifier form is NNNxxx: where NNN is OSB - Oceanographic Spectral Bulletin, and xxx takes the form: mnn - where m is the wave model and nn is the number of the point in a given geographic location according to note 2 above. nn can range from 01 - 99.

5. m is the wave model where:

   N is the NOAA WAVEWATCH III global wave model
   A is the Alaska Waters regional wave model
   W is the Western North Atlantic regional wave model
   H is the North Atlantic Hurricane regional wave model
   E is the Eastern North Pacific regional wave model
   P is the Eastern Pacific Hurricane regional wave model
   X is the Western North Pacific regional wave model
   T is the Western Pacific Typhoon regional wave model

Table 2. The center frequencies and corresponding band widths with center period by frequency bin.

bin number	center frequency (Hz)	frequency band width (Hz)	center period (s)
1	.0418	.00399	23.94
2	.0459	.00439	21.76
3	.0505	.00482	19.79
4	.0556	.00531	17.99
5	.0612	.00584	16.35
6	.0673	.00642	14.87
7	.0740	.00706	13.51
8	.0814	.00777	12.29
9	.0895	.00855	11.17
10	.0985	.00940	10.15
11	.1083	.01034	9.23
12	.1192	.01138	8.39
13	.1311	.01251	7.63
14	.1442	.01376	6.93
15	.1586	.01514	6.30
16	.1745	.01666	5.73
17	.1919	.01832	5.21
18	.2111	.02015	4.74
19	.2322	.02217	4.31
20	.2555	.02438	3.91
21	.2810	.02682	3.56
22	.3091	.02951	3.24
23	.3400	.03246	2.94
24	.3740	.03570	2.67
25	.4114	.03927	2.43

Table 3. WMO GRIB bulletin header descriptors.

T_1	T_2[1]	A_1[2]	A_2	dd	Station id
O	A B C J K M N P Y	M	A C E G I J K L M X N Y O P Q Z R S T U	88	KWBJ

Where:

T_1 is the bulletin type descriptor: O - oceanographic.
T_2 is the parameter descriptor, see notes below.
A_1 is the grid and domain descriptor: M - 0.25° x 0.25° lon/lat grid over domain from 98.25°W to 29.75°W and from 0.25°S to 50.25°N..
A_2 is the forecast hour descriptor, see notes below.
dd is the surface descriptor: 88 - ocean surface.

Notes:

1. Parameter descriptors

A - u-wind component
B - v-wind componentC - Total significant wave height
J - Peak wave period
K - Peak wave direction
M - Peak wind sea period
N - peak wind sea direction
P - D_mY - T_m

2. Forecast hour descriptors at 6-h intervals from 0- to 72-h and at 12-h intervals from 72- to 168-h.

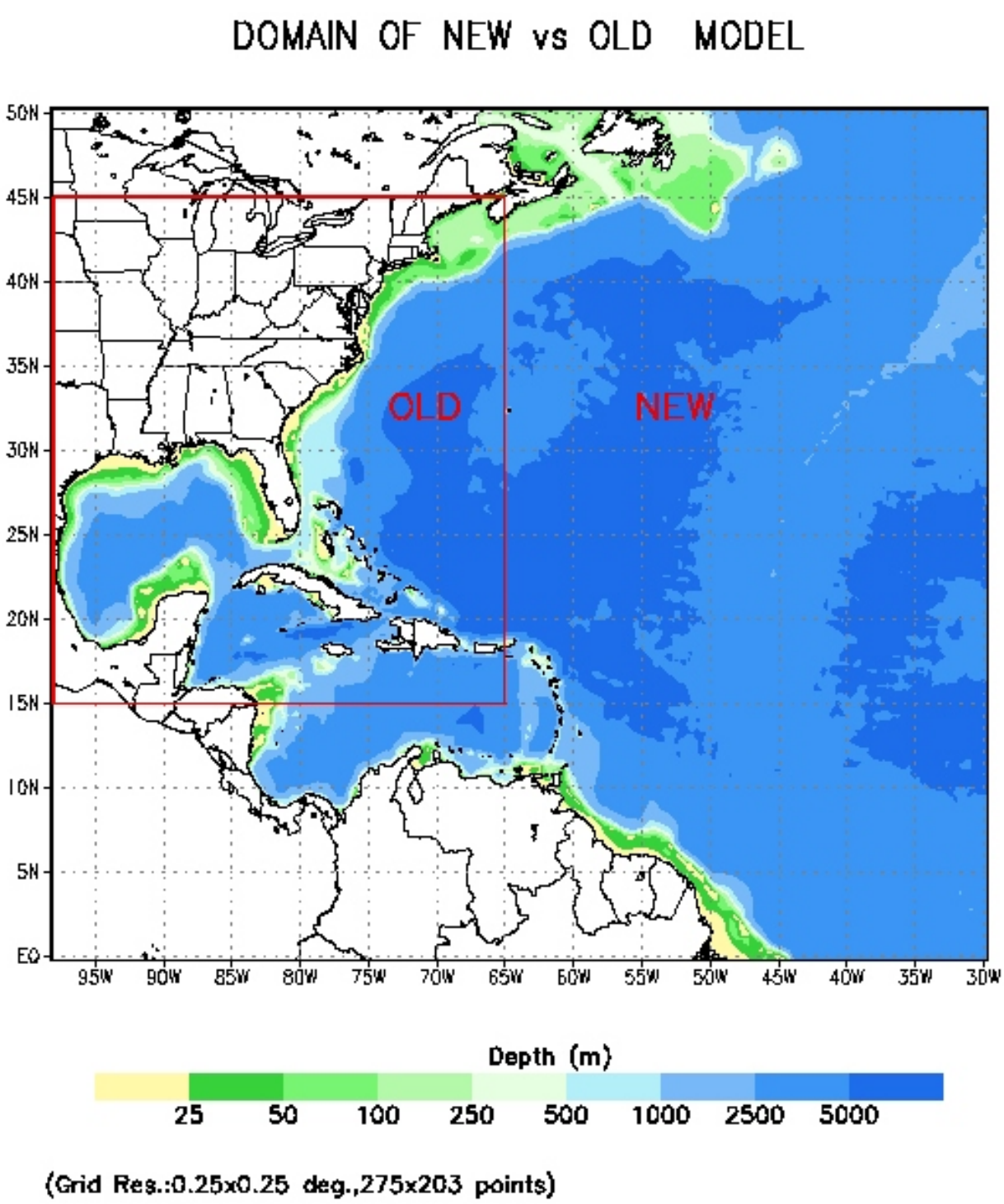

Figure 1. Domain of Western North Atlantic regional wave model with depths in meters. The highlighted box shows the domain of the replaced ECGM.